Nuclear Propulsion through Direct Conversion of Fusion Energy

Completed Technology Project (2011 - 2012)

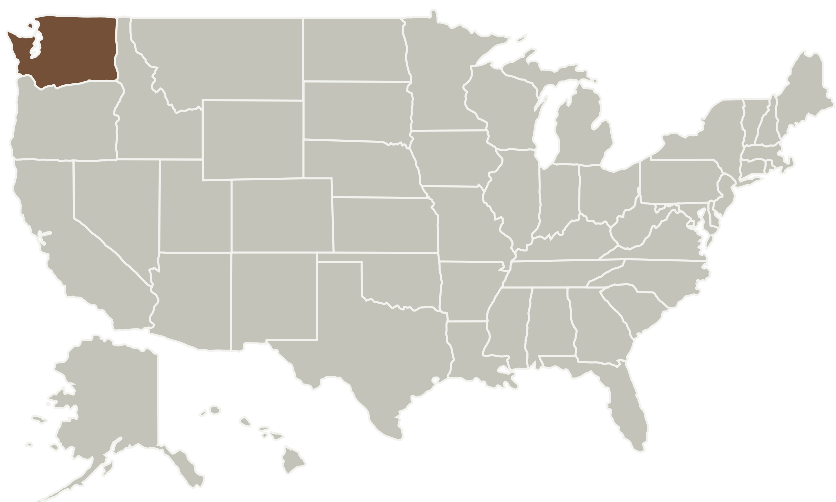
Project Introduction

The future of manned space exploration and development of space depends critically on the creation of a vastly more efficient propulsion architecture for in-space transportation. Nuclear-powered rockets can provide the large energy density gain required. A small scale, low cost path to fusion-based propulsion is to be investigated. It is accomplished by employing the propellant to compress and heat a magnetized plasma to fusion conditions, and thereby channel the fusion energy released into heating only the propellant. Passage of the hot propellant through a magnetic nozzle rapidly converts this thermal energy into both directed (propulsive) energy and electrical energy.

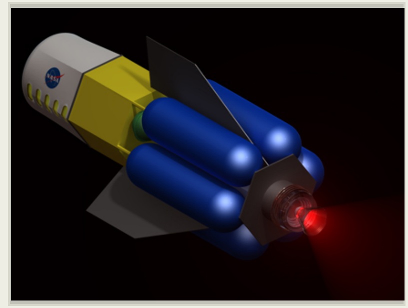
Anticipated Benefits

The development of this technology can enable a dramatically more efficient propulsion architecture for in-space transportation.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
MSNW, LLC	Lead Organization	Industry	Redmond, Washington
Iowa State University	Supporting Organization	Academia	Ames, Iowa



Nuclear Propulsion through Direct Conversion of Fusion Energy Project

Table of Contents

Primary U.S. Work Locations

Washington

Project Transitions

September 2011: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

MSNW, LLC

Responsible Program:

NASA Innovative Advanced Concepts

Project Management

Program Director:

Jason E Derleth

Program Manager:

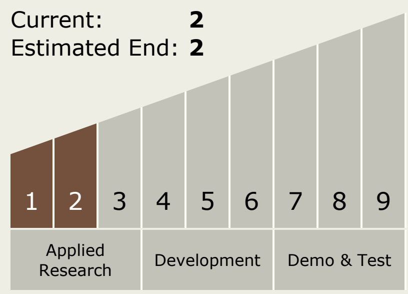
Eric A Eberly

Principal Investigator:

John Slough

Technology Maturity (TRL)

Start: **1**
Current: **2**
Estimated End: **2**



September 2012: Closed out

Closeout Summary: The future of manned space exploration and development of space depends critically on the creation of a dramatically more proficient prop ulsion architecture for in-space transportation. A very persuasive reason for inve stigating the applicability of nuclear power in rockets is the vast energy density gain of nuclear fuel when compared to chemical combustion energy. Current nuc lear fusion efforts have focused on the generation of electric grid power and are wholly inappropriate for space transportation as the application of a reactor base d fusion-electric system creates a colossal mass and heat rejection problem for s pace application. The Fusion Driven rocket (FDR) represents a revolutionary app roach to fusion propulsion where the power source releases its energy directly in to the propellant, not requiring conversion to electricity. It employs a solid lithiu m propellant that requires no significant tankage mass. The propellant is rapidly heated and accelerated to high exhaust velocity (> 30 km/s), while having no si gnificant physical interaction with the spacecraft thereby avoiding damage to th e rocket and limiting both the thermal heat load and radiator mass. In addition, it is believed that the FDR can be realized with little extrapolation from currently existing technology, at high specific power (~ 1 kW/kg), at a reasonable mass s cale (<100 mt), and therefore cost. If realized, it would not only enable manned interplanetary space travel, it would allow it to become common place. The key to achieving all this stems from research at MSNW on the magnetically driven i mplosion of metal foils onto a magnetized plasma target to obtain fusion conditi ons. A logical extension of this work leads to a method that utilizes these metal shells (or liners) to not only achieve fusion conditions, but to serve as the propel lant as well. Several low-mass, magnetically-driven metal liners are inductively driven to converge radially and axially and form a thick blanket surrounding the target plasmoid and compress the plasmoid to fusion conditions. Virtually all of t he radiant, neutron and particle energy from the plasma is absorbed by the enc apsulating, metal blanket thereby isolating the spacecraft from the fusion proces s and eliminating the need for large radiator mass. This energy, in addition to th e intense Ohmic heating at peak magnetic field compression, is adequate to vap orize and ionize the metal blanket. The expansion of this hot, ionized metal prop ellant through a magnetically insulated nozzle produces high thrust at the optim al Isp. The energy from the fusion process, is thus utilized at very high efficienc y. During phase I the metal foil convergence and compression physics has been analyzed analytically as well as modeled in 3D with the ANSYS Multiphysics cod e. These results were used to extend modeling to the ongoing 2D resistive Magn etohydrodynamic analysis of the fusion plasma compression. The initial determin ation of the optimum compression methodology, materials, and fuels to achieve required fusion power and specific mass for various missions has been performe d, and a systems-level model along with the initial propulsion system design has been carried out and is presented as well. A range of both manned and unmann ed missions was considered for which this fusion propulsion system would be en abling or critical. Manned mission architecture to Mars similar to the NASA Desig n Reference Mission (DRM) 3.0 was considered as part of a mission analysis for t wo mission designs - a 90 and 30 day trip to/from Mars with a discussion of the results for various fusion gains for the FDR. Expanding on these results from the phase I, the phase II effort will focus on achieving three key criteria for the Fusi on Driven Rocket to move forward for technological development: (1) the physic s of the FDR must be fully understood and validated, (2) the design and technol ogy development for the FDR required for its implementation in space must be f ully characterized, and (3) an in-depth analysis of the rocket design and spacecr aft integration as well as mission architectures enabled by the FDR need to be p

Technology Areas

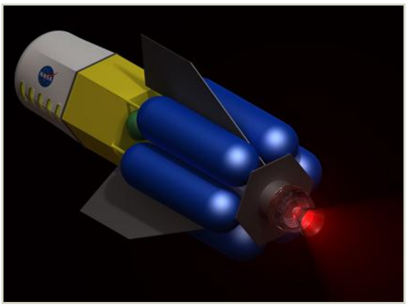
Primary:

- TX01 Propulsion Systems
  └ TX01.4 Advanced Propulsion
    └ TX01.4.4 Other Advanced Propulsion Approaches

Target Destinations

Others Inside the Solar System, Outside the Solar System

Images



Project Image Nuclear Propulsion through Direct Conversion of Fusion Energy
Nuclear Propulsion through Direct Conversion of Fusion Energy Project
(https://techport.nasa.gov/image/102141)